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SEVENTY-FIFTH

ANNUAL REPORT

OF THE

DIRECTOR

OF

THE ASTRONOMICAL OBSERVATORY

OF

HARVARD COLLEGE

FOR THE YEAR ENDING SEPTEMBER 30, 1920

BY

S. I. BAILEY

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THE OBSERVATORY

To the President of the University: —

Sir, — The work of the Astronomical Observatory during the past year has consisted chiefly in carrying onward toward completion the various researches begun under the supervision of the late Director, Edward C. Pickering. Special studies, however, have been undertaken, which are referred to below under the different departments.

In spite of financial difficulties, the publication of the Henry Draper Catalogue of stellar spectra has made good progress. We may hope, at the present rate, to complete the printing of this great work within three years. The demand for the remaining volumes is still urgent. A limited amount of publication has been done also in other lines, but the printing of the greater part of the material, which has been ready for a long time, has been delayed and is liable to indefinite postponement unless additional funds become available. It is evident that hereafter the greatest brevity consistent with accuracy will be necessary.

The year has yielded interesting results in the systematic search for new stars. Four such objects have been discovered, two by Miss Mackie and two by Miss Woods. Some of these have aroused the interest of astronomers at the other large American observatories. Also, a third maximum of the unusual star, T Pyxidis, was found during this search by Miss Woods. The preceding maxima occurred in 1890 and 1902. This star is related by the characteristics of its spectrum to novae having a single maximum. The four novae discovered in 1920 and the two in 1919 are all found in a small area of the Milky Way, between sixteen and twenty hours of right ascension. The remaining area, although examined with equal care during this time, yielded no new star. The brilliant new star in Cygnus, first seen by Denning of England, has been carefully followed and a fairly complete record of its changes in brightness and spectrum has been obtained. A bright nova is likely to be found more promptly visually than photographically, since the photographic method involves a certain delay. This star, however, was present on Harvard plates before its maximum and would have

been found in regular order within two or three days. So many observers in different parts of the world are now watching the sky that a brilliant new star can hardly escape notice more than a few hours, while objects fainter than the third or fourth magnitude might easily be overlooked. The photographic survey extends to about the ninth or tenth magnitude, and in many cases to much fainter stars. During this search, twenty new variables were discovered. This number is much less than might have been expected and indicates that the recent survey of the sky for the detection of variable stars was reasonably complete for the stars examined. Also, known novae were found 17 times, known variables 230, asteroids 16, and planets 25 times. These results furnish a check on the thoroughness of the search.

The astronomical fellowships for women have been filled by Miss Mary D. Applegate and Miss Antonia C. Maury. Miss Applegate has taken part in the measurement of novae and variable stars, and Miss Maury has been engaged in a study of the orbits of spectroscopic binaries discovered at this Observatory.

Dr. Joel H. Metcalf has undertaken an examination of some of the early and late plates of the northern sky for the detection of stars of large proper motion. Mr. Metcalf is carrying on this investigation by means of a "Blink" comparator constructed by himself. A systematic research of this nature should lead to results of much value.

Henry Draper Memorial

Much time has been spent by Miss Cannon in supervising the publication of the Henry Draper Catalogue. The first six volumes have now been issued or sent to the printer. The copy for the remaining volumes, **97**, **98**, and **99**, is entirely ready, and only lack of funds prevents their immediate publication. The demand for individual spectra from the unpublished volumes still continues, and, during the last few months, about 1500 have been sent to astronomers in this country and abroad.

A discussion of the spectrum of Nova Aquilae, No. 3, including a short comparative study of the spectra of all the novae, fifteen in number, which appear on the Harvard photographs, has been published; also, lists of spectra whose peculiarities led to the discovery of seventy-three new double stars and six new variable stars. A study of the spectrum of Nova Cygni, No. 3, has been commenced. Its light curve has been unusually regular, and the startling changes

which took place in the spectrum of Nova Aquilae, No. 3, have not yet occurred.

Considerable work has also been done by Miss Cannon on the subject of the distribution of the spectra of all the stars classified in the Henry Draper Catalogue. The spectra of some peculiar objects, including η Carinae, have been studied on all available plates.

The total number of plates exposed at Cambridge, under the direction of Professor King, was 4050, of which 3571 were photographs of the stars. The number of successful plates taken for the position of the Moon was 71. An adequate number of plates has been taken for the position of Uranus and Neptune. Plates have been taken, also, in the search for a transneptunian planet according to data furnished by Professor W. H. Pickering.

The work with the 8-inch Draper Telescope, using the out-of-focus method, for the photovisual magnitudes of stars and bright planets has been continued. Care has been taken to photograph the planets on ordinary plates also, whenever the photovisual values were found, in order to eliminate the effect of phase on the color indices.

In continuation of the work begun previously, some measures of the light of the sky have been made, using both blue and yellow light. These measures will determine the color index of the sky.

For determining and testing the elements for the orbits of spectroscopic binaries, charts of standard velocity-curves have been prepared by Professor King, which are applicable to any star, if its curve be drawn to the standard linear lengths for period and amplitude. Another set of curves shows the relation between eccentricity and periastron distance from the node.

In extension of the systematic methods used with the 1-inch Cooke lens for the prompt discovery of new stars, the list of regions for the Voigtländer lens, which photographs a circular area of the sky 60° or more in diameter, has been arranged to cover practically all the sky every clear evening. On alternate nights the centers of the plates come at the corners of the regions photographed the preceding night. In winter it is possible in a single night to cover all the sky except small portions low in the north and in the south. In summer the work requires perhaps two nights.

A slide rule for converting Cambridge Sidereal Time into Greenwich Mean Time (decimals of a day) has been made by Professor King, and its use has been found expeditious as well as accurate for the purpose.

The 7½-inch Cooke Triplet lens of the Maria Mitchell Nantucket Observatory has been tested with the result that the central component was adjusted to give much improved images.

Boyden Department

Arequipa Station. — The Arequipa Station has remained in charge of Mr. F. E. Hinkley, assisted by Señor J. E. Muñiz. In all, 3243 photographs of the sky were made. Two thousand two hundred and ninety-nine of these were taken with the 10-inch Metcalf Telescope for the determination of photographic magnitudes. The plates needed for this investigation can probably be completed within a year or two. The dome of the 13-inch Boyden Telescope, which had been in use about thirty years and had become unmanageable, has been equipped with a new rail and trucks. An effort has been made to maintain all the instruments and buildings in suitable repair.

Mandeville Station. — The Mandeville Station has continued under the direction of Professor W. H. Pickering. The planet Mars has been observed throughout the year, which precluded the usual series of measures of the shapes and rotation of Jupiter's satellites. The main features of this apparition have been the increasing numbers of the canals, which as anticipated reached their maximum at the time of the summer solstice of the planet. The diminished radius of curvature of the polar canals indicates a reduced velocity of the polar winds with the diminished size of the snow cap. The appearance of equatorial frosts and the sudden appearance, for a brief period, of extensive snow storms give a clue to the temperature conditions of the surface. An unusually prolonged duration of cloud over the south polar regions and temperate zone was observed. A report of these matters has been prepared, and will shortly be published. Drawings from the other members of the International Association have been received and will form another report.

Detailed observations of the lunar craters Conon and Eratosthenes have been continued, with especial relation to the appearance within and around them of snow and vegetation. A paper on each has already appeared, and another on the latter crater is now nearly ready for publication, in which by both drawings and micrometer measurements the daily changes in shape and dimensions of the dark patches due to vegetation are illustrated.

Considerable time has been given to locating the unknown planet whose orbit lies next beyond Neptune, and accordant results have

been already obtained. It is hoped to issue a statement shortly. Popular articles have been published on Relativity, the Time Relations of Astronomy and Geology, on Planetary Genesis, on Meteors, and Novae.

Photographic Magnitudes

This work has been continued under the supervision of Miss Leavitt. The taking of plates in series, with the 16-inch Metcalf Telescope, for the comparison of stars in selected regions with those of the North Polar Sequence is nearly completed, and the plan for covering the northern sky with similar plates is progressing. The number of series is 13 with blue, and 7 with yellow light. With the 10-inch Metcalf Telescope at Arequipa 71 series were taken with blue and 117 series with yellow light for the comparison of all parts of the southern sky with Harvard Standard Regions at the declination +15°. These plates have been of exceptionally fine quality during the past year. About 25,000 measures have been made of the brightness of stars in sequences, mainly in the southern heavens. The measurements of stars in twenty sequences within five degrees of the North Pole have been completed. An important feature of the work, as usual, has been the observation of variable stars and other objects of interest, especially novae. Many requests for information concerning suspected objects have been answered. The variables in the Nebula of Orion have been the subject of detailed study. Within the year the material for determining the magnitudes of comparison stars for the variables in the Magellanic Clouds has become available, and a beginning has been made in observing the brightness of these objects, more than 1700 in number. The number of estimates of brightness of variable stars was about 10,000.

Variable Stars

Mr. Campbell has observed variable stars with the 12-inch and 15-inch telescopes, when too faint to be seen with the smaller instruments used by amateur observers, or when they would otherwise be neglected. With the photometers attached to these instruments he has secured 7061 settings, of which 2536 were of the minor planets, for evidence of variation in light, 496 of Nova Cygni, No. 3, 524 of Algol and short period variables, and 413 of six eclipses of Jupiter's satellites. The remaining settings were of special variables, principally of long period, and of comparison stars.

Contributions have been received from the members of The American Association of Variable Star Observers, from observers in foreign countries, including Dr. J. M. Baldwin, of Victoria, Australia, and the Variable Star Section of the Cape Astronomical Association, South Africa, under the guidance of Mr. J. F. Skjellerup. The aid of the Director of the McCormick Observatory in supplying data when the variables are faint has been invaluable.

In all, 18,437 observations by 76 observers have been made or communicated as follows: —

J. F. Skjellerup, 1346; G. B. Lacchini, 1301; L. C. Peltier, 1226; C. Y. McAteer, 1169; J. M. Baldwin, 1137; L. Campbell, 1060; McCormick Observatory, 951; H. C. Bancroft, Jr., 699; A. W. Long, 696; T. C. H. Bouton, 571; D. B. Pickering, 517; E. de Perrot, 479; E. W. Janczewski, 441; A. S. Young, 407; C. S. Mundt, 384; N. V. Ginori, 376; R. G. Chandra, 368; E. W. Clement, 326; B. H. Dawson, 301; T. S. Kimball, 261; A. Bemporad, 249; H. O. Eaton, 239; J. E. G. Yalden, 226; W. T. Olcott, 222; N. Tapia, 214; P. W. Merrill, 209; S. L. Rhorer, 209; I. Yamamoto, 208; H. W. Vrooman, 182; S. C. Hunter, 154; S. Bunch, 143; C. C. Godfrey, 118; C. E. Barns, 115; E. E. Barnard, 111; L. M. Jenkins, 109; F. J. Carr, 106; M. J. Jordan, 100; R. O. Suter, 100. Besides these, 1407 observations were communicated by 39 observers, each of whom made less than 100 estimates.

The discussion of all these observations of long period variables has been carried on by Mr. Campbell, and numerous mean light curves have been carefully determined. These curves are remarkably complete and enable one to predict future dates of maxima and minima with considerable accuracy.

About 650 photographic charts of variable star regions have been furnished to observers, including a large number to the Chart Committee of The American Association of Variable Star Observers, which is making a complete revision of its charts on the Harvard scale of magnitude.

Mr. Howard Eaton, a graduate student of the University, has made photometric observations of a few variables and of new sequences of comparison stars.

Some progress has been made in the systematic study of the variable stars in the globular clusters.

Construction and Equipment

Professor Gerrish, as in other years, has had charge of the department of Mechanical Engineering, and has also acted as business executive of the Observatory. Rigid economy has been necessary. Sufficient repairs have been made to prevent undue deterioration of plant and equipment. Much of this work has been done by the regular Observatory employees, thus avoiding the employment of outside labor at the present high rates.

A new type of polarizing photometer is under construction in which the readings are to be automatically printed upon a strip of paper. By the use of this instrument it is expected that the services of a recorder will be dispensed with, the observer being enabled to record his own observations.

Miscellaneous

Phillips Library. — Nine hundred volumes and pamphlets have been added to the Library during the year, making the total number at the present date 57,216.

Telegraphic Announcements. — For many years the Harvard College Observatory has been the American center for the distribution of astronomical news, whether domestic or foreign. The great war caused some interruption in this service. At its close, the International Astronomical Union was formed, under the auspices of the International Research Council. A Committee on Astronomical Telegrams was appointed, and the Royal Observatory at Uccle (Brussels) was made the head of the service, with the Harvard College Observatory the distributing center for North and South America. During the year twenty-one telegraphic announcements were made. As heretofore, cablegrams from any part of the two Americas should be addressed to Observatory, Boston, and telegrams, to Harvard College Observatory, Cambridge, Mass.

Thirty-seven Bulletins have been issued, making 731, in all. These Bulletins supplement the telegraphic service, and make announcements of new stars, comets, variable stars, and other important astronomical news.

Publications. — The following Annals have been published during the year: — **81**, No. 2, The Light Curve of Nova Aquilae, No. 3; **81**, No. 3, The Spectrum of Nova Aquilae, No. 3; **81**, No. 4, Photovisual Magnitudes of Stars and Planets; **82**, No. 3, The Transneptunian Planet; **83**, No. 4, Observations and Investigations made at the Blue Hill Meteorological Observatory in the year 1919; **84**,

No. 4, Discussion of Thirteen Circumpolar Variables; and **94**, The Henry Draper Catalogue, 9^h, 10^h, and 11^h. **84**, No. 5, Photographic Light Curves of Eleven Novae, and **95**, The Henry Draper Catalogue, 12^h, 13^h, and 14^h, are in type, and **96**, The Henry Draper Catalogue, 15^h and 16^h, nearly so. Two circulars have also been issued, as follows: —

220. Maxima in 1920 of Variable Stars of Long Period. December 1, 1919.

221. Stars having Composite Spectra. Seventy-three New Double Stars.
Stars having Peculiar Spectra. Six New Variable Stars. January 28, 1920.

S. I. BAILEY, *Acting Director.*